U.S. Environmental Protection Agency Region 7

Middle Fork Salt River
Monroe, Randolph, Shelby, and Macon Counties, Missouri

Total Maximum Daily Load

September, 2006

Approved by:

/s/ 11/01/2006

William A. Spratlin **Date**
Director
Water, Wetlands, and Pesticides Division

Total Maximum Daily Load (TMDL)
Middle Fork Salt River
Pollutant: Sediment

Name: Middle Fork Salt River

Location: Monroe, Randolph, Shelby, and Macon Counties, Missouri

Hydrologic Unit Code (HUC): 07110006

Water Body Identification (WBID): 0121

Missouri Stream Class: Class P[1]

Beneficial Uses[2]:

- Irrigation
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)
- Whole Body Contact Recreation (Category B)
- Secondary Contact Recreation
- Drinking Water Supply

Size of Impaired Segment: 49 miles

Location Description of Impaired Segment[3]: From Section 9, 54N, 9W to 16, 56N, 13W (refer to Table H 10 CSR 20-7).

Pollutant: Sediment

Pollutant Source: Agricultural Nonpoint Source

TMDL Priority Ranking: Low

[1] Class P streams maintain permanent flow during drought conditions. See 10 CSR 20-7.031(1)(F)
[2] For Beneficial Uses see 10 CSR 20-7.031(1)(C) and Table H.
[3] See Table H 10 CSR 20-7

1. Introduction

This Middle Fork Salt River Total Maximum Daily Load (TMDL) for sediment is being established in accordance with Section 303(d) of the Clean Water Act, because the State of Missouri determined on the 1998 and 2002 303(d) lists of impaired waters that the water quality standards (WQS) for Middle Fork Salt River were exceeded due to sediment. To meet the milestones of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001, EPA is establishing this TMDL.

The purpose of a TMDL is to determine the pollutant loading a waterbody can assimilate without exceeding the WQS for that pollutant. The TMDL also establishes the pollutant load allocation necessary to meet the WQS established for each waterbody based on the relationship between pollutant sources and in-stream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA), and margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources. The LA is the fraction of the total pollutant load apportioned to non-point sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumption and data inadequacies.

2. Background and Water Quality Problems

Middle Fork Salt River is located in the South Fork Salt River Basin (HUC 07110006), and flows from Macon to Monroe County. Forty-nine miles of Middle Fork Salt River is listed as impaired by sediment. The associated watershed is approximately 348 square miles with predominant land use of grassland, cropland, and deciduous forest (Table 1 and Figure 1). The primary cause of the sediment impairment to Middle Fork Salt River has been identified as pollution caused by agricultural non-point sources.

Table 1: Land Use Distribution for Middle Fork Salt River Watershed

Type	Percent
Barren or Sparsely Vegetated	<1
Cropland	29
Deciduous Forest	20
Deciduous Woody/Herbaceous	2
Evergreen Forest	<1
Grassland	43
Herbaceous-Dominated Wetland	<1
High Density Urban	<1
Impervious	2
Low Intensity Urban	<1
Open Water	<1
Woody-Dominated Wetland	3

All waters of the State, as per Missouri WQS, must provide suitable conditions for aquatic life. The conditions include both the physical habitat and the quality of the water. TMDLs are not written to address habitat, but are written to correct water quality conditions. Because the water body addressed by this TMDL was assessed as to its biological function, many factors may have contributed to the impairment. The State of Missouri continues to do field evaluation and in the future, may define the role sediment is playing in the potential biological impairment of this waterbody. However, the water quality condition for which the Middle Fork Salt River is currently listed is sedimentation; therefore, this TMDL addresses sediment. The State of Missouri may submit and EPA may approve another TMDL or a modified 303d listing for this water at a later time to address new information on the impairment.

A combination of natural geology and land use in the prairie portions of the state (where Middle Fork Salt River is located) is believed to have reduced the amount and impaired the quality of habitat for aquatic life. The major problems are excessive rates of sediment deposition due to stream bank erosion and sheet erosion from agricultural lands, loss of stream length and loss of stream channel heterogeneity due to channelization, and changes in basin hydrology that have increased flood flows and prolonged low flow conditions. Loss of tree cover in riparian zones has caused elevated water temperatures in summer and a reduction in woody debris, a critical aquatic habitat component in prairie streams. The most compelling evidence of loss or impairment of aquatic habitat is the historical changes in the distribution of fishes in Missouri. Many species of fish no longer appear in portions of the State where they once lived (MDNR, 2005). All waters of the State, as per Missouri WQS, must provide a suitable home for aquatic life. The conditions include both the physical habitat and the quality of the water. TMDLs are not written to address habitat, but are written to correct water quality conditions.

Middle Fork Salt River was placed on the Missouri 303(d) list for sedimentation. This was primarily based on best professional judgment because little sediment data exists to directly document sediment impacts to the stream. General fisheries data and the effect of sediment on fish were the initial data used to consider Middle Fork Salt River for 303(d) listing. For this TMDL, sediment targets were derived using generalized information from the ecological drainage unit (EDU).

Since the 303(d) listing, MDNR has developed a sediment protocol to determine if sediment is actually the pollutant in the streams listed and to arrive at a standard way to measure sediment. The first step of that protocol is a biological assessment to see if the biological community is actually impaired. A biological assessment was not available for this waterbody.

3. Description of Sources

3.1 Point Sources

Twenty-two National Pollutant Discharge Elimination System (NPDES) permitted facilities are located within the watershed (Table 2). Macon Wastewater

Treatment Facility (WWTF) is located in Macon County, with a design flow of 2.5 MGD. Macon County has one major municipal WWTF with five separate outfalls and one minor non-municipal Grain Processor facility with five separate outfalls, both of which discharge treated effluent to tributaries of Middle Fork Salt River. Monroe County has one minor municipal and one minor non-municipal WWTF (City of Paris and USDA Building) discharging treated effluent to Middle Fork Salt River. In Randolph County there are two minor municipal WWTFs (Jacksonville and Cairo) and one minor non-municipal facility (BSA, Camp Thunderbird) discharging treated effluent.

Livestock in the watershed include many horses, cattle, and hogs held in pastures, feedlots, and Concentrated Animal Feeding Operations (CAFO). Six operations are registered, certified or permitted within the watershed (Table 2). CAFOs are animal feeding operations in which animals are confined to areas that are totally roofed. CAFOs typically utilize earthen or concrete structures to contain and store manure prior to land application.

All permitted livestock facilities have waste management systems designed to minimize runoff entering their operations or detaining runoff emanating from their areas. Such systems are designed for the 25-year, 24-hour rainfall/runoff event. NPDES permits, also non-discharging, are issued for facilities with more than 1,000 animal units (AU). Total potential animal population for all facilities is approximately 8,891 AUs. The actual number of AUs on site is variable, but typically less than potential numbers.

Table 2. Permitted Facilities

Facility	**Permit number**	**County**	**Design Flow (MGD)**
CAFOs			
Swine Assurance Production	MO-G010001	Monroe	Non discharging
Nobis North Unit	MO-G010026	Monroe	Non discharging
Greenwood, John Hog Farm	MO-G010137	Macon	Non discharging
Ensor, Charles (Outfall 01 and 02)	MO-G010437	Monroe	Non discharging
Greenwood, Eric Hog Farm	MO-G010517	Macon	Non discharging
Z-Base Farms Inc.	MO-G010569	Monroe	Non discharging
Other			
Macon WWTF (Outfall 01, 02, 03, 04 and 05)	MO-0023221	Macon	2.5
Farmers Mutual Insurance	MO-0038776	Macon	0.001
Dan Arnold Lagoon	MO-0057088	Macon	0.004
Jacksonville WWTF	MO-0097527	Randolph	0.02
Paris WWTF	MO-0100234	Monroe	0.2
Cairo WWTF	MO-0103390	Randolph	0.061
BSA, Camp Thunderbird	MO-0120073	Randolph	0.025
USDA Building WWTF	MO-0122556	Monroe	0.001
NE MO Grain Processors (Outfalls 01- 05)	MO-0124575	Macon	0.917

MFA Bulk Plant-Macon	MO-G350066	Macon	Storm water, dewatering
Leo O'Laughlin Inc.-Macon	MO-G490370	Macon	Storm water, dewatering
APAC Central MO-Div Paris	MO-G490562	Monroe	Storm water, dewatering
Bleigh Ready Mix B-6	MO-G490590	Monroe	Storm water, dewatering
Thompson Bros. Ready-Mix	MO-G490864	Macon	Storm water, dewatering
W.L. Miller Company – MAC	MO-G490981	Macon	Storm water, dewatering
Clarence Cannon WTP	MO-G640073	Monroe	Storm water, dewatering

3.2 Non-Point Sources

Most of the watershed is grassland (43%), cropland (29%), or deciduous forest (20%). Cropland that is adjacent to and drains into Middle Fork Salt River could contribute to the sediment impairment. In addition to the six NPDES-permitted CAFOs in the watershed there are other livestock (Table 3). Overland runoff can easily carry sediment from these agricultural areas into the stream. Soil, from exposed land, runs into the creek, increasing the turbidity and concentration of total suspended solids (TSS) and decreasing the transparency. Background levels of TSS come from natural fluvial processes. Sediment becomes suspended during high flow events as soil along the banks is eroded and bed sediment is resuspended. Sediment loading in Middle Fork Salt River comes predominantly from nonpoint source pollution.

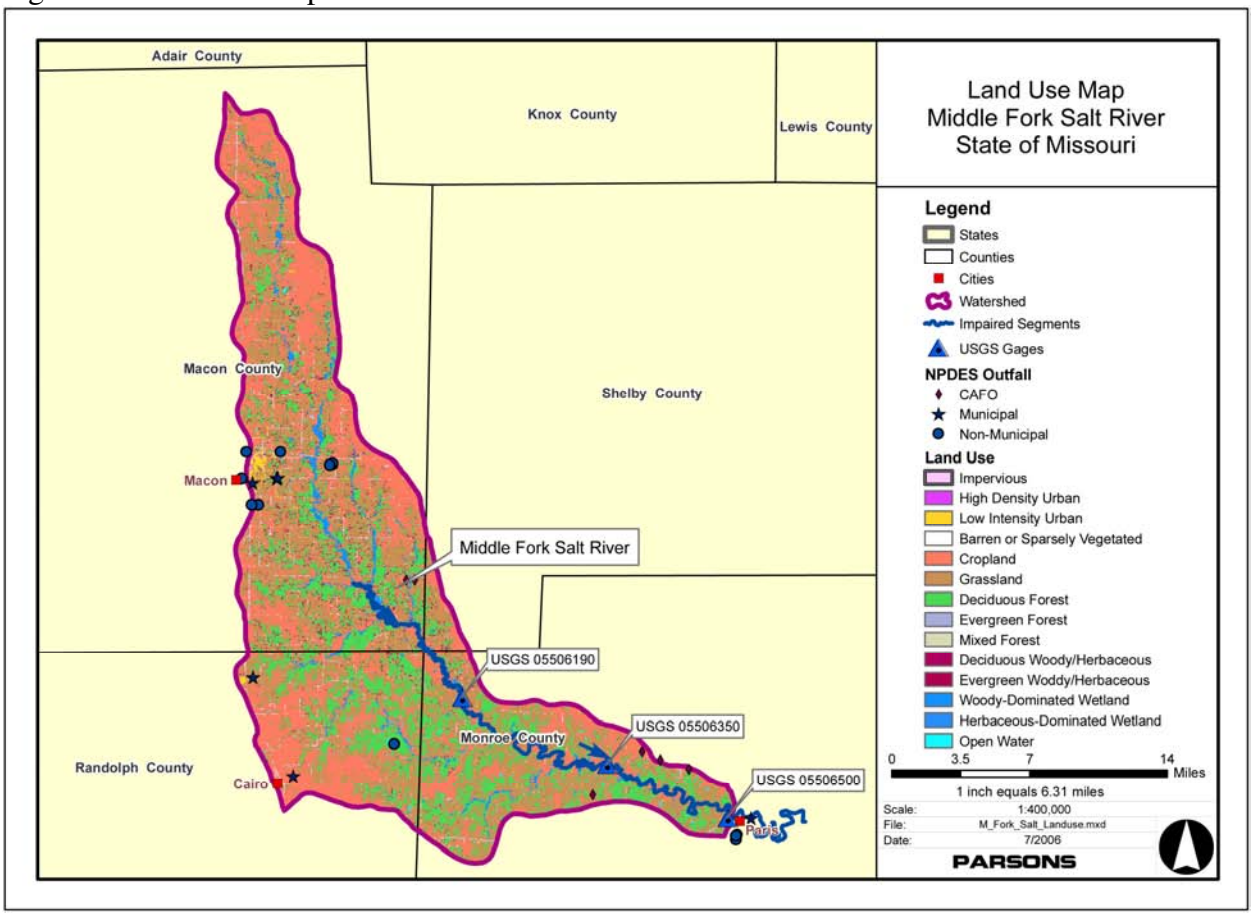
Table 3. Livestock Estimates per County[4]

Livestock and Poultry	Animal Units		
	Macon	Monroe	Randolph
Cattle			
Beef	26,893	17,285	14,432
Milk	279	1,053	269
Cow/Calf	49,552	37,637	29,829
Hogs/Pigs	20,652	52,049	38,336
Sheep/Lambs	2,231	1,867	831
Poultry			
Layers	1,126	692	1,889
Broilers	354	(D)	1,472

(D) Withheld to avoid disclosing data for individual farms.

[4] USDA- NASS Quick Stats (Livestock) 2002 Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data http://www.nass.usda.gov/census/census02/volume1/mo/st29_2_001_001.pdf

Figure 1. Land Use Map for Middle Fork Salt River Watershed



4. Description of the Applicable WQS and Water Quality Targets

4.1 Beneficial Uses

Middle Fork Salt River has the following beneficial uses:

- Irrigation
- Livestock and Wildlife Watering
- Protection of Warm Water Aquatic Life
- Human Health Protection (Fish Consumption)
- Whole Body Contact Recreation (Category B)
- Secondary Contact Recreation
- Drinking Water Supply

The stream classifications and designated uses may be found at 10 CSR 20-7.031(1)(C) and (F) and Table H.

Use that is impaired:

- Protection of Warm Water Aquatic Life

4.2 Antidegradation Policy

Missouri's WQS include the U.S. Environmental Protection Agency (EPA) "three-tiered" approach to antidegradation, and may be found at 10 CSR 20-7.031(2).

Tier 1 – Protects existing uses and provides the absolute floor of water quality for all waters of the United States. Existing in-stream water uses are those uses that were attained on or after November 29, 1975, the date of EPA's first WQS Regulation, or uses for which existing water quality is suitable unless prevented by physical problems such as substrate or flow.

Tier 2 – Protects the level of water quality necessary to support the propagation of fish, shellfish, and wildlife and recreation in and on the water in waters that are currently of higher quality than required to support these uses. Before water quality in Tier 2 caters can be lowered, there must be an antidegradation review consisting of: (1) a finding that it is necessary to accommodate important economical or social development in the area where the waters are located; (2) full satisfaction of all intergovernmental coordination and public participation provisions; and (3) assurance that the highest statutory and regulatory requirements for point sources and best management practices (BMPs) for non-point sources are achieved. Furthermore, water quality may not be lowered to less than the level necessary to fully protect the "fishable/swimmable" uses and other existing uses.

Tier 3 – Protects the quality of outstanding national resources, such as waters of national and state parks, wildlife refuges and waters of exceptional recreational or ecological significance. There may be no new or increased discharges to these waters and no new or increased discharges to tributaries of these waters that would result in

lower water quality (with the exception of some limited activities that result in temporary and short-term changes in water quality).

4.3 Narrative Criteria

The impairment of this waterbody is based on exceedence of the general, or narrative, criteria contained in Missouri's WQS, 10 CSR 20-7.031(3)(A), (C) and (G).

(A) Waters shall be free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or prevent full maintenance of beneficial uses;
(B) Waters shall be free from substances in sufficient amounts to cause unsightly color or turbidity, offensive odor or prevent full maintenance of beneficial uses;
(G) Waters shall be free from physical, chemical or hydrologic changes that would impair the natural biological community.

When the WQS is expressed as a narrative value, a measurable indicator of the pollutant may be selected to express the narrative as a numeric value. There are many quantitative indicators of sediment, such as, TSS, turbidity, and bedload sediment, which are appropriate to describe sediment in rivers and streams.[5] TSS was selected as the numeric target for this TMDL because it enables the use of the highest quality data available, including permit conditions and monitoring data.

5. Calculation of Load Capacity

Load capacity (LC) is defined as the maximum pollutant load that a waterbody can assimilate and still attain WQS. This total load is then divided among a WLA for point sources, a LA for nonpoint sources and a MOS. The LC for this TMDL has been defined as a load duration curve (LDC) over the range of flows for Middle Fork Salt River, see Figure 2, where the solid (red) curve is the TMDL. Based on Figure 2, the TMDL targets up to a near 100% reduction in sediment load over the range of flows. Round (black) points are loads calculated from the measured concentrations in the stream and any corresponding horizontal bars (red) are the percent reduction required to meet the TMDL.

5.1 Modeling Approaches

In the case of Middle Fork Salt River where narrative standards are targeted for the impaired stream, a reference approach is used. In this approach, the target for pollutant loading is the 25th percentile of the current EDU condition calculated from all data available within the EDU in which the waterbody is located. Therefore, the 25th percentile is targeted as the TMDL load duration curve. For a full description of the development of suspended sediment targets using reference load duration curves refer to

[5] Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria, U.S. Environmental Protection Agency, EPA-822-R-06-001, May 2006.

Appendix B. Specific data sources for this TMDL's flow and EDU-wide TSS data are listed in Appendix C. Table 4 shows estimates of discharge at flow percentiles.

Figure 2: TMDL Allocation and Percent Reduction for Middle Fork Salt River.

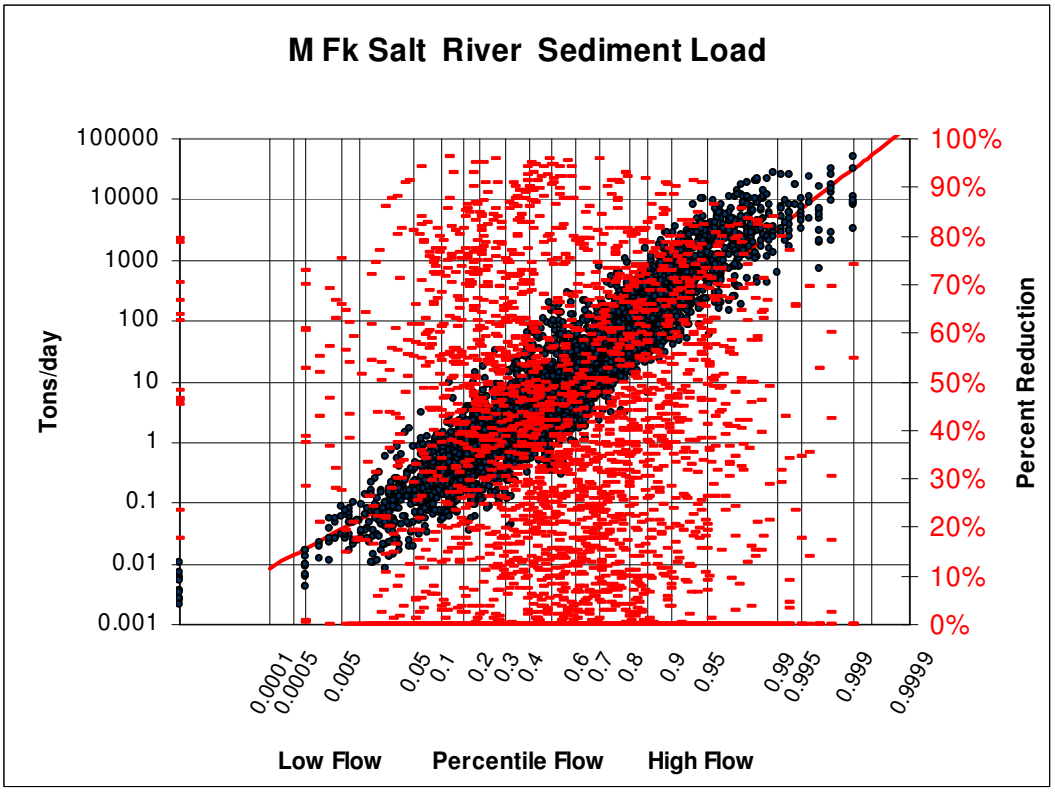


Table 4: Estimated Flow for Range of Percentiles at the Impaired Segment Outlet

	Percent of Flow	Discharge (cubic feet per second)
Flow Estimate for Middle Fork Salt River Based on Drainage Area and Synthetic Ecological Drainage Unit Flow	10	4.0
	30	15.7
	50	41.6
	70	114
	90	526

6. Waste Load Allocation (Point Source Loads)

WLA is the allowable amount of the pollutant that can be assigned to point sources. The WLA is set to the lesser of current permit limits or technology based effluent limits (TBELs). TBELs are defined in a permit based on facility type. Mechanical WWTFs' permit limits are a weekly average TSS concentration of 45 mg/L and a monthly average TSS concentration of 30 mg/L. Secondary equivalent WWTFs' permit limits are a weekly average TSS concentration of 60 mg/L and a monthly average

TSS concentration of 45 mg/L. Waste water treatment lagoon facilities' permit limits are up to a weekly average TSS concentration of 120 mg/L and a monthly average TSS concentration of 80 mg/L. Additionally, permits can be written to target lower limits if the specific facility is capable of performance exceeding TBELs. Table 5 lists the site specific permitted point sources in the watershed and WLAs based on their current permit limits and permitted design flows. In addition any general permits need further evaluation to determine if a site specific permit is needed to address sediment loading. Based on the assessment of sources, point sources do not contribute to water quality impairment relative to sediment impacts on stream biology. Thus, the WLAs are zero percentage net reduction in sediment load. These facilities' WLAs are set at the current permit limits and conditions. The WLAs listed in this TMDL do not preclude the establishment of future point sources of sediment loading in the watershed. Any future point sources should be evaluated in light of the TMDL established and the range of flows into which any additional load will impact.

Table 5. WLAs for site specific permitted facilities in Middle Fork Salt River watershed.

Facility	**Permit number**	WLA (tons per day) d / w / m*
Macon WWTF -Outfall 01, (02-05 are CSO outfalls)	MO-0023221	NA / 0.47 / 0.31
Farmers Mutual Insurance	MO-0038776	NA / 0.0005 / 0.0003
Dan Arnold Lagoon	MO-0057088	NA / 0.002 / 0.001
Jacksonville WWTF	MO-0097527	NA / 0.01 / 0.007
Paris WWTF	MO-0100234	NA / 0.04/ 0.02
Cairo WWTF	MO-0103390	NA / 0.03 / 0.02
BSA, Camp Thunderbird	MO-0120073	NA / 0.005 / 0.003
USDA Building WWTF	MO-0122556	NA / 0.0005 / 0.0003
NE MO Grain Processors (Outfall 01, 02, 03, 04 and 05)	MO-0124575	0.178 / NA / 0.108

**Permit limits based on current design loads where d=daily, w=weekly average, m=monthly average.*

Macon's WWTF Combined Sewer Outfalls (CSO) outfalls are required to comply with the Nine Minimum Controls for Combined Sewer Outfalls as specified by U.S. EPA's combined sewer overflow policy dated April 19, 1994 (59 CFR 18688). A long term management plan has outlined a Phase One to address treatment of CSOs by reducing inflows to the combined sewer.

All other listed facilities (Table 2) have general permits. The WLAs are set at present loads and listing of permit specific BMPs. Additionally, these permits should be reevaluated to determine if general permits are sufficient to protect the impaired segment.

Stormwater runoff from all permitted facilities also discharges to the stream. Compliance with the Missouri Storm Water Permit will ensure construction sites meet the TMDL area weighted loadings. Permittees with general permits beginning with "MOG35" will develop a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP

ensures the design, implementation, and maintenance of Best Management Practices (BMPs). EPA assumes that construction activities in the watershed will be conducted in compliance with Missouri's Storm Water Permit including monitoring and discharge limitations. Compliance with this permit should lead to sediment loadings from the construction site at or below applicable targets.

General Permits with numbers beginning "MO-G49" limit non-stormwater discharges to a TSS concentration of 70 mg/L. General permits with numbers beginning "MO-G64" limit backwash outfalls to settleable solids of 1.0mL/L. Without designated flows the load can not be estimated but these concentration limits give a relative measure for potential impact of sediment loading from these facilities.

7. Load Allocation (Non-point Source Loads)

LA is the allowable amount of the pollutant that can be assigned to non-point sources. The LA is set to 90% of the TMDL (Figure 2). Based on measured data from the river, the percentage of reduction in sediment load ranges to nearly 100% over the range of flows.

8. Margin of Safety

A MOS is added to a TMDL to account for uncertainties inherent in calculations and data gathering. The MOS is intended to account for such uncertainties in a conservative manner. Based on EPA guidance, the MOS can be achieved through one of two approaches:

1) Explicit – Reserve a numeric portion of the loading capacity as a separate term in the TMDL.
2) Implicit – Incorporate the MOS as part of the critical conditions for the WLA and the LA calculations by making conservative assumptions in the analysis.

Available data for Middle Fork Salt River shows instances where load exceeds the TMDL (Figure 2). To account for uncertainties in the modeling an explicit 10% MOS is assigned to this TMDL. For example, at the flow probability of 0.5 (median flow), the TMDL is approximately 3.9 tons/day and the MOS 0.4 tons/day.

9. Seasonal Variation

The TMDL curve represents flow under all seasonal conditions. The LA and TMDL are applicable at all flow conditions, hence all seasons. The advantage of a LDC approach is to avoid the constraints associated with using a single-flow critical condition during the development of a TMDL. Therefore, all flow conditions including seasonal variation are taken into account for TMDL calculations.

10. Monitoring

No future monitoring has been scheduled for Middle Fork Salt River at this time. However, the department will routinely examine physical habitat, water quality, invertebrate community, and fish community data collected by the Missouri Department of Conservation under its Resource Assessment and Monitoring (RAM) Program. This program randomly samples streams across Missouri on a five to six year rotating schedule.

11. Public Participation

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). EPA is providing public notice of this TMDL for Middle Fork Salt River on the EPA, Region 7, TMDL website: http://www.epa.gov/region07/water/tmdl_public_notice.htm. The response to comments and final TMDL will be available at: http://www.epa.gov/region07/water/apprtmdl.htm#Missouri.

This water quality limited segment of Middle Fork Salt River in Monroe, Macon, Randolph and Shelby Counties, Missouri, is included on the EPA approved 1998 and 2002 303(d) lists for Missouri. This TMDL is being produced by EPA to meet the requirements of the 2001 Consent Decree, *American Canoe Association, et al. v. EPA*, No. 98-1195-CV-W in consolidation with No. 98-4282-CV-W, February 27, 2001. EPA is developing this TMDL in cooperation with the State of Missouri, and EPA is establishing this TMDL at this time to fulfill the *American Canoe* consent decree obligations. Missouri may submit and EPA may approve another TMDL for this water at a later time.

As part of the public notice process, MDNR assists EPA by providing a distribution list of interested persons to which EPA will provide an announcement of the Middle Fork Salt River TMDL. Groups that receive the public notice announcement include the Missouri Clean Water Commission, the Missouri Water Quality Coordinating Committee, Stream Team Volunteers in the county, county legislators, and potentially impacted cities, towns and facilities. The EPA public noticed this TMDL from September 22, 2006, to October 22, 2006, and the Summary of Response to Comments is posted on the EPA website: http://www.epa.gov/region07/water/apprtmdl.htm#Missouri.

12. References

Framework for Developing Suspended and Bedded Sediments (SABS) Water Quality Criteria, U.S. Environmental Protection Agency, EPA-822-R-06-001, May 2006.

Missouri Department of Natural Resources (MDNR) (2005). Total Maximum Daily Load (TMDL) Information Sheet For Streams with Aquatic Habitat Loss that are Listed for Sediment, http://www.dnr.mo.gov/env/wpp/tmdl/info/habitat-info.pdf

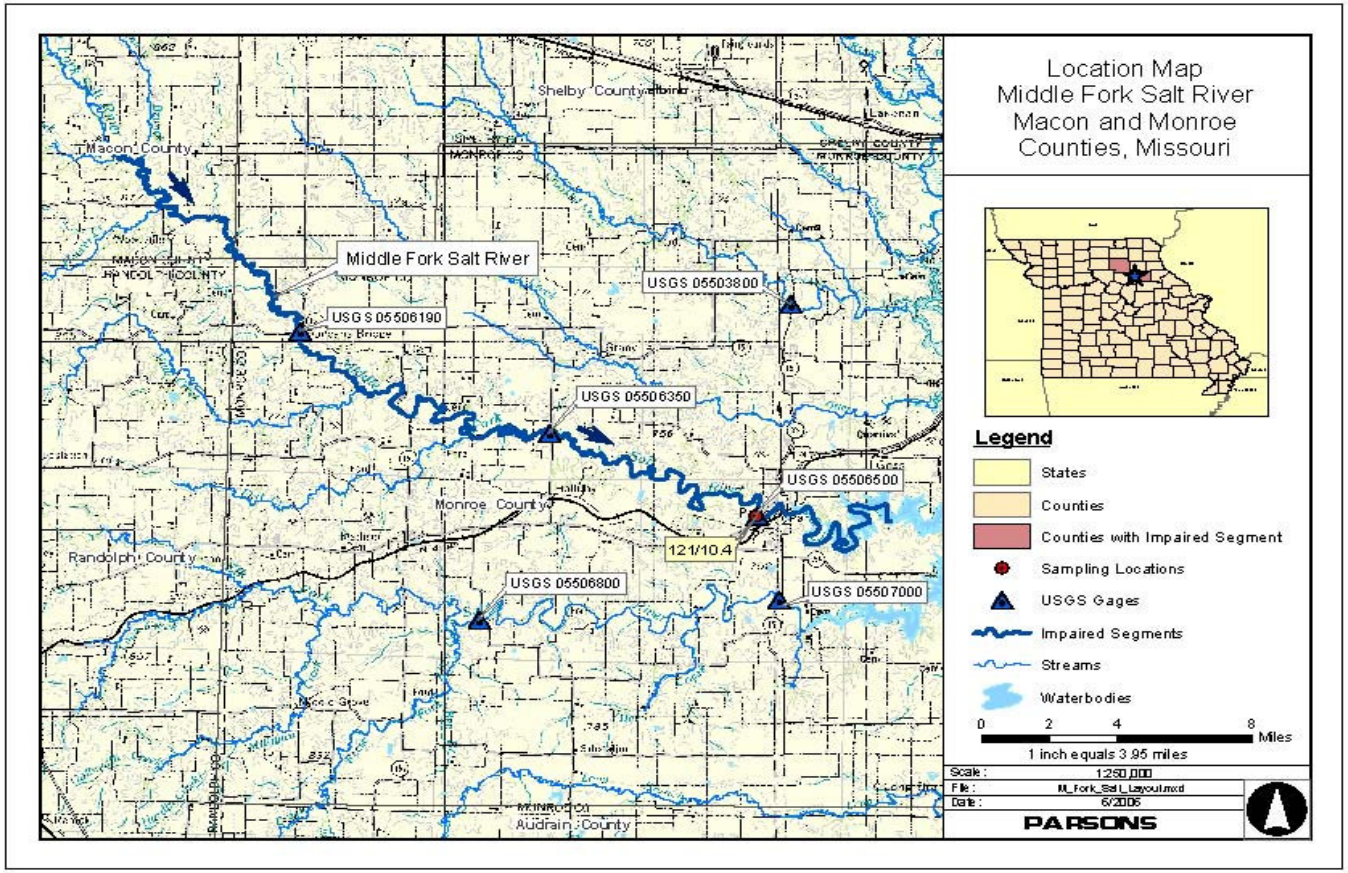
Missouri Department of Natural Resources (MDNR) (2007). Quality Assurance Project Plan for Wasteload Allocations/Special Studies

Kansas Department of Health and Environment (KDHE) (2000). Upper Wakarusa River TMDL (Sediment Impact on Aquatic Life), http://www.kdheks.gov/tmdl/klr/UpWakaTSS.pdf and Little Arkansas River TMDL (Sediment Impact on Aquatic Life), http://www.kdheks.gov/tmdl/la/LittleArkSed.pdf

USDA (2002). NASS Quick Stats (Livestock) Census of Agriculture, Volume 1 Chapter 2: Missouri County Level Data http://www.nass.usda.gov/census/census02/volume1/mo/st29_2_001_001.pdf

13. Appendices

Appendix A: Location Map for Middle Fork Salt River
Appendix B: Development of Suspended Sediment Targets using Reference Load Duration Curves
Appendix C: Data sources Used to Develop TMDL



Appendix A: Location Map for Middle Fork Salt River

Appendix B

Development of Suspended Sediment Targets using Reference Load Duration Curves

Overview

This procedure is used when a lotic system is placed on the 303(d) impaired waterbody list for a pollutant and the designated use being addressed is aquatic life. In cases where pollutant data for the impaired stream is not available a reference approach is used. The target for pollutant loading is the 25th percentile calculated from all data available within the ecological drainage unit (EDU) in which the waterbody is located. Additionally, it is also unlikely that a flow record for the impaired stream is available. If this is the case a synthetic flow record is needed. In order to develop a synthetic flow record calculate an average of the log discharge per square mile of USGS gaged rivers for which the drainage area is entirely contained within the EDU. From this synthetic record develop a flow duration from which to build a load duration curve for the pollutant within the EDU.

From this population of load durations follow the reference method used in setting nutrient targets in lakes and reservoirs. In this methodology the average concentration of either the 75th percentile of reference lakes or the 25th percentile of all lakes in the region is targeted in the TMDL. For most cases available pollutant data for reference streams is also not likely to be available. Therefore follow the alternative method and target the 25th percentile of load duration of the available data within the EDU as the TMDL load duration curve. During periods of low flow the actual pollutant concentration may be more important than load. To account for this during periods of low flow the load duration curve uses the 25th percentile of EDU concentration at flows where surface runoff is less than 1% of the stream flow. This results in an inflection point in the curve below which the TMDL is calculated using this reference concentration.

Methodology

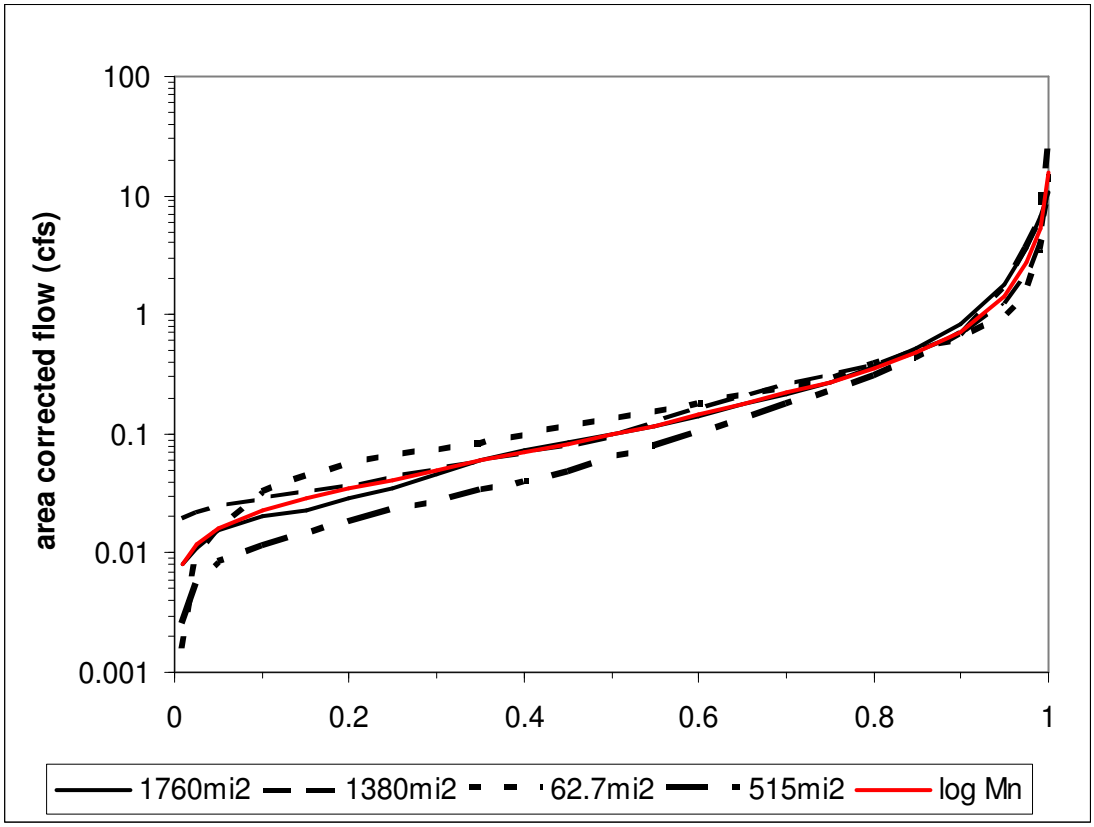
The first step in this procedure is to locate available pollutant data within the EDU of interest. These data along with the instantaneous flow measurement taken at the time of sample collection for the specific date are recorded to create the population from which to develop the load duration. Both the date and pollutant concentration are needed in order to match the measured data to the synthetic EDU flow record.

Secondly, collect average daily flow data for gages with a variety of drainage areas for a period of time to cover the pollutant record. From these flow records normalize the flow to a per square mile basis. Average the log transformations of the average daily discharge for each day in the period of record. For each gage record used to build this synthetic flow record calculate the Nash-Sutcliffe statistic to determine if the

relationship is valid for each record. This relationship must be valid in order to use this methodology. This new synthetic record of flow per square mile is used to develop the load duration for the EDU. The flow record should be of sufficient length to be able to calculate percentiles of flow.

The following examples show the application of the approach to one Missouri EDU.

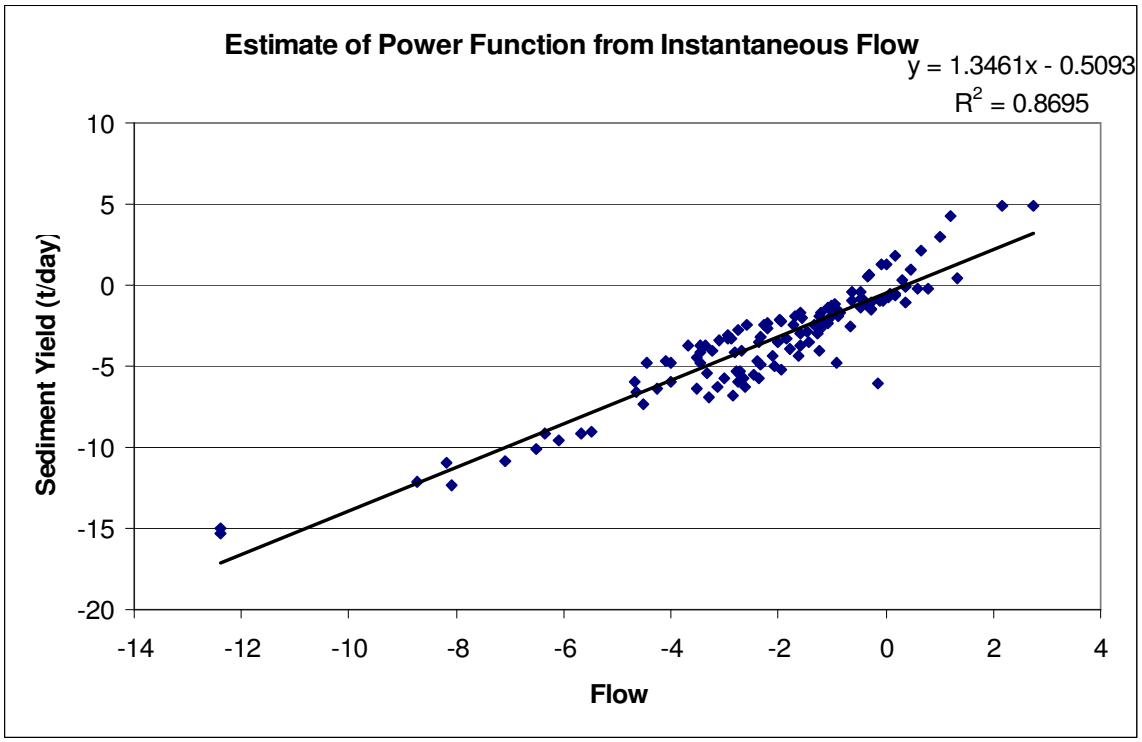
The watershed-size normalized data for the individual gages in the EDU were calculated and compared to a pooled data set including all of the gages. The result of this analysis is displayed in the following figure and table:



Gage	gage	area (mi^2)	normal Nash-Sutcliffe	lognormal Nash-Sutcliffe
Platte River	06820500	1760	80%	99%
Nodaway River	06817700	1380	90%	96%
Squaw Creek	06815575	62.7	86%	95%
102 River	06819500	515	99%	96%

This demonstrates the pooled data set can confidently be used as a surrogate for the EDU analyses.

The next step is to calculate pollutant-discharge relationships for the EDU, these are log transformed data for the yield (tons/mi^2/day) and the instantaneous flow (cfs/mi^2.) The following graph shows the EDU relationship:



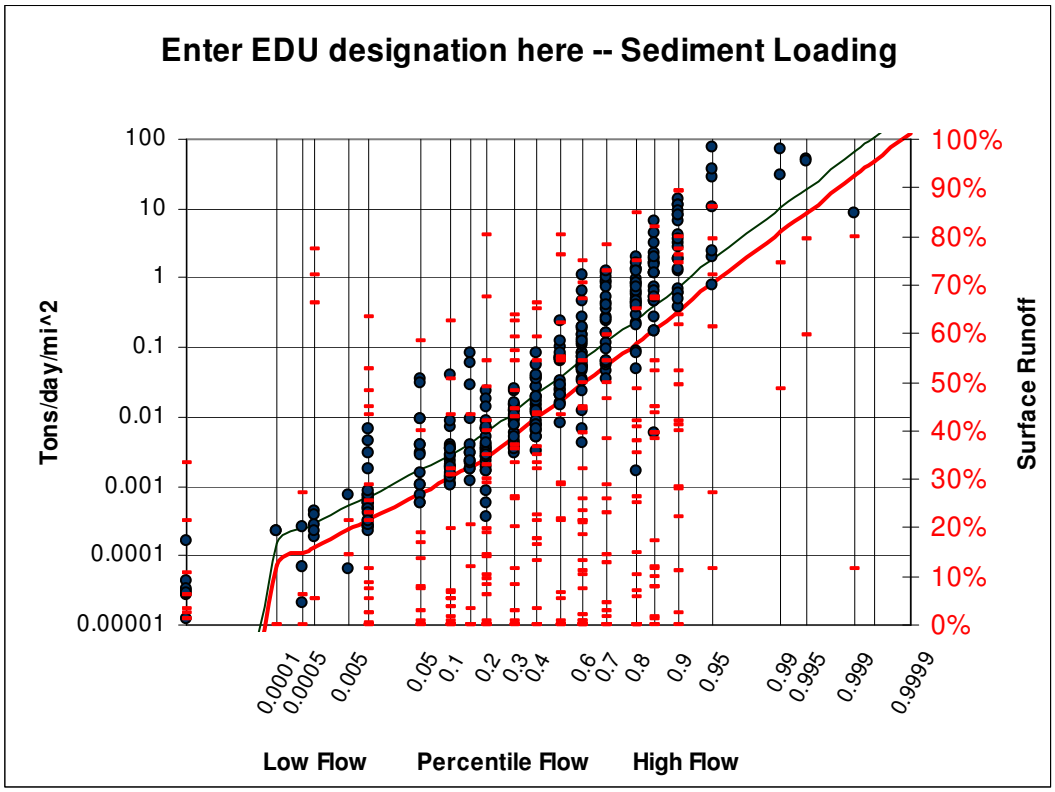
Further statistical analyses on this relationship are included in the following Table:

m	1.34608498	b	-0.509320019
Standard Error (m)	0.04721684	Standard Error (b)	0.152201589
r^2	0.86948229	Standard Error (y)	1.269553159
F	812.739077	DF	122
SSreg	1309.94458	SSres	196.6353573

The standard error of y was used to estimate the 25%ile level for the TMDL line. This was done by adjusting the intercept (b) by subtracting the product of the one-sided Z_{75} statistic times the standard error of (y). The resulting TMDL Equation is the following:

*Sediment yield (t/day/mi^2)=exp(1.34608498 * ln (flow) - 1.36627)*

A resulting pooled TMDL of all data in the watershed is shown in the following graph:



To apply this process to a specific watershed would entail using the individual watershed data compared to the above TMDL curve that has been multiplied by the watershed area. Data from the impaired segment is then plotted as a load (tons/day) for the y-axis and as the percentile of flow for the EDU on the day the sample was taken for the x-axis.

For more information contact:
Environmental Protection Agency, Region 7
Water, Wetlands, and Pesticides Division
Total Maximum Daily Load Program
901 North 5th Street
Kansas City, Kansas 66101
Website: http://www.epa.gov/region07/water/tmdl.htm

Appendix C

Data sources Used to Develop TMDL

USGS stream gages used to generate synthetic flow:

Wyaconda River above Canton, MO	05496000
North Fabius at Monticello, MO	05497000
Middle Fabius River near Monticello, MO	05498000
South Fabius River near Taylor, MO	05500000
North Fork Salt River near Shelbina, MO	05502500

USGS stream sample sites used to generate EDU TMDL:

Middle Fabius River nr Monticello, MO	05498000
Salt River nr Shelbina, MO	05502500
Salt River nr Hunnewell, MO	05503500
South Fork Salt River at Santa Fe, MO	05505000
Youngs Creek nr Mexico, MO	05506000
Middle Fork Salt River nr Paris, MO	05506500
Elk Fork Salt River nr Paris, MO	05507000